E diesel®: A California Status Report

Non-Petroleum Fuels: Working Groups Conference

Report of the E diesel® Working Group

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Diesel Market Overview

- **Diesel emissions under global assault (public health, etc.)**
- **Global policies challenge OEMs, operators, refiners & marketers to meet environmental challenges**
- **Targeted emissions from diesel: NOx, CO, PM & air toxics**
- **Many emerging fuel, hardware solutions are quite costly, some still untested, and many require major infrastructure and engine changes**
- **Fleets affected include: urban transit vehicles, delivery & service fleets, construction and other off-road equipment**
- **U.S. market: >50 billion gals. -- vast, growing fast, & highly segmented (on- vs. off-road, mobile vs. stationary, etc.)**

What is E diesel®?

A diesel fuel using conventional diesel blendstock(s) with:

- **Up to 15vol% anhydrous ethanol (ASTM D 4806),**
- **Stabilized with ~0.6 - 5.0vol% proprietary additive(s), plus**
- **Cetane enhancement (where required)**

In addition to emissions benefits, E diesel® offers:

- **<u>Premium Diesel</u> performance: lubricity (HFRR), stability (Octel F-21), conductivity (NACS), cold temp. operability**
- **Little or no infrastructure or fuel system changes**
- **Ease of use in heavy-duty on- & off-road CI engines**

What is E diesel®? (continued)

Why Ethanol is an Ideal Diesel Oxygenate

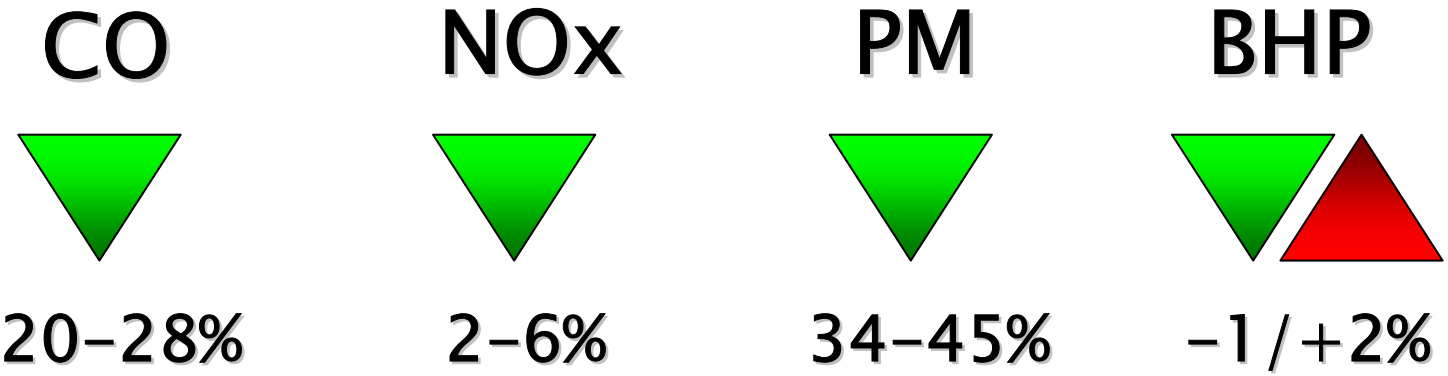
- **Benefits:**
  - **Renewable, domestically-produced replacement for imported petroleum fuel components**
  - **No significant environmental side-effects**
  - **Widely proven as a gasoline oxygenate in world markets including U.S., Canada & Brazil**
  - **Supply & infrastructure already exists in key global markets (~4 billion gals./yr. U.S. capacity - 2004)**
  - **Greenhouse gas reductions**

Typical E diesel® Emissions Benefits

O_2Diesel, Inc. Emissions Testing

Colo. School of Mines, Southwest Research Institute, Environment Canada: Nov. 1999 – Sept. 2003

EPA No.2 Diesel vs. No.2 O_2Diesel™ (7.7vol% ethanol)



EPA 13-mode Transient Cycle Engine Testing

(DDC Series 60, Navistar DT-466 engines)

John Deere E diesel® Evaluation: Aug. 2004
Three New Tier II Certified Engines
7.7, 10, and 15vol% Ethanol-Diesel Blends
Southwest Research Institute

J.D. Engine Type (# cyl. + disp.)	6068H (6 cyl., 6.8L)	6081H (6 cyl., 8.1L)	6125H (6 cyl., 12.5L)
Visible Smoke	-11% to -58%	-39% to -61%	-23% to -58%
Particulate Matter (PM)	-4% to -22%	-16% to -30%	-13% to -19%
Carbon Monoxide (CO)	+3% to +24%	-6% to -14%	-15%
Hydrocarbons (HC) + NOx	-7% to -9%	+1% to +2%	-4%

Summary of Selected E diesel® Fleet Demo Test Results

Ease of logistics, distribution, and handling

- "Fill & Go" clean fuel solution
- Little or no infrastructure or engine changes
- Excellent cold weather operability
- Visible and measurable emission benefits

Good engine performance and driveability

- Fuel is fully fungible with regular diesel
- No reported mileage demerits (urban fleets)
- Economics better than other technologies

No capital investment required

E diesel® in California – Current Status

- **O_2Diesel, Inc. obtained "Alternative Diesel Verification" status from CARB for its E diesel® product – Sept. 23, 2003. *www.arb.ca.gov/fuels/diesel/altdiesel/092303o2dsl.pdf***
- **O_2Diesel™ designated as a "Developmental Engine Fuel" by the Division of Measurement Standards of Calif. Dept. of Agriculture (pending ASTM specification) – Sept. 2003.**
- **O_2Diesel™ reviewed by California State Fire Marshal according to agency policies & regulations – Sept. 2003.**
- **O_2Diesel, Inc. is launching fleet programs, in addition to various demonstrations, in compliance with regulations.**
- **O_2Diesel, Inc. launching CARB "Diesel Emissions Control Strategy" (DECS) Levels 1, 2, & 3 verification testing (2004)**

E diesel® Technical Agenda: 2004

- **"Ethanol-Blended Diesel Fuel Handbook" (DOE Argonne National Laboratories) – release pending**
- **Uniform Safety and Handling procedures -- Evaluation begun in 2001/02 at Southwest Research Institute (SwRI)**
- **Greenhouse gas impact analysis by Argonne National Labs (Michael Wang, et al)**
- **Health effects testing required per Section 211(b) of the Clean Air Act – Tier 1 complete (2 companies submitted)**
- **John Deere cooperative test program (>$2 million + 2 years) – SwRI durability phase of testing now underway (3 engines, 3 E diesel® formulations)**

E diesel® Consortium: Technical Issues

- Determining materials compatibility & durability
- Establishing storage & handling requirements
- Managing flashpoint & flammability (FMEA, SwRI, and NREL analyses – see next slide)
- Designing ASTM/CGSB fuel standards (started in 2003)
- Completing all required EPA & CARB verification testing
- Obtaining additional emissions benefits (other blends?)
- Addressing all other OEM issues
- Complying with federal, state & local laws & regulations

Independent E diesel® Safety Assurance Tests: NREL, SwRI

Flame arrestor designs that prevent tank ignition demonstrated:

- Worst case scenario test
- 100% success at preventing ignition for the four tank designs tested

Reduces risks associated with using this renewable fuel blend

FreedomCAR and Biomass Program collaboration, co-funded by State of Illinois

Access report at (NREL/SR-540-34301):
http://www.nrel.gov/docs/fy03osti/34301.pdf

E diesel® Consortium: Organization

- Draft Consortium Charter approved Dec. 4, 2001
- Not-for-Profit Organization established under aegis of the Renewable Fuels Foundation
- Consortium began work in early 2002
- Significant technical & regulatory agenda (2002 - 06)
- Broad industry/government participation
- See website www.e-diesel.org for complete details

E diesel® Consortium: Members

- Illinois “Core Group” (original E diesel® Task Force)
- Major U.S. ethanol producers (ADM, Abengoa, Aventine)
- Additive suppliers (Lubrizol, O2Diesel, Inc.)
- U.S. Dept. of Energy (including NREL, Argonne Nat’l. Lab)
- Renewable Fuels Association (U.S. and Canada)
- National Corn Growers Association (and state chapters)
- State & local, public & private groups (OEMs welcome!)

"Business-as-Usual" Scenario

Approach & Assumptions

- "VEETC" opens federal ethanol incentive (52 cents per gallon of ethanol) for all market niches (passed U.S. Congress on Oct. 11, 2004).
- Federal excise tax incentive extended through Dec. 2010 (from present 2007 expiration date).
- Opens far wider market for ethanol-diesel blended fuels, on- and off-road, regardless of taxpayer status.
- Minimum 8.3vol% non-petroleum (7.7vol% ethanol + 0.6vol% min. renewable additive package) displacement likely from 2007 – 2010.
- On-road centrally-fueled HD fleets & engines in California (assuming up to 20% penetration) represent ~540 million gal./yr. market potential (2002), increasing to about 585 million gals. in 2010, 615 million gallons in 2015, and 647 million gals. by 2020.
- Some OEM technical, acceptance & other issues remain.

"Business-as-Usual" Scenario

Approach & Assumptions (continued)

- **The identified California off-road market includes off-highway and construction, commercial, farming, industrial, and mining.**
- **Off-road California market potential access (assuming 50% total penetration): 340 million gals./yr. in 2002.**
- **By 2010, the total potential market potential would be in the range of 369 million gallons, or about 44 million gallons of E diesel®.**
- **By 2015, market potential could reach 615 million gallons, of which almost 185 million would be E diesel®.**
- **By 2020, market potential would reach 814 million gallons, or about 130 million gallons of E diesel®.**
- **Total on- and off-road market potential (2020): ~1 billion gallons, or *about 161 million gallons of E diesel®.***

"Aggressive Case " Scenario

Approach & Assumptions

- Target blending level (average) of 10vol% ethanol by 2010.
- Target blending level of 15vol% ethanol by 2020.
- All OEM technical and other issues resolved: benefits of oxygenating diesel fuel with ethanol fully recognized.
- Federal excise tax incentive extended through 2020 and California adopts in-state producer or other incentive.
- Market penetration increases in all niches under "Business as Usual" scenarios.
- Fuel ethanol remains priced according to CaRFG demand requirements, and wholesale CaRFG prices remain lower relative to ULSD, CARB diesel, etc.
- Diesel demand worldwide continues to grow at a faster pace than gasoline, increasing price pressure.
- Does not include other petroleum displacement options (e.g., source of additive, other blend components, etc.)

"Aggressive Case" Scenario

Approach & Assumptions (continued)

- **Assumption:** E diesel® blends eventually capture 50% of each selected market niche (2010 and later).
- Centrally-fueled fleets would represent a 585 million gallon market and would be expected to achieve about 29 million of E diesel® consumption in 2010.
- This market segment would grow to 647 million gallons in 2020, of which 323 million would be E diesel®.
- Off-road demand for E diesel® at the 50% or greater level could reach nearly 37 million gallons by 2010, and 407 million by 2020.
- By 2020, total centrally-fueled fleet and off-road demand would reach 730 million gallons of E diesel®, representing potential consumption of 73 million gallons of ethanol at 10vol% blends or 110 million gallons at 15vol% blends.

Summary of E diesel® Market Potential

2010 – 2020 Scenarios: California Centrally-Fueled & Off-Road Fleet Vehicles

Year	*Business as Usual* (7.7vol% blends)	*Aggressive Case* (10vol%+ blends)
2010	*55 million gallons* (4.2 million gals. of ethanol)	*66 million gallons* (~7 million gals. of ethanol)
2015	*106 million gallons* (8.1 million gals. of ethanol)	*417 million gallons* (42 million gals. of ethanol)
2020	*161 million gallons* (12.4 million gals. of ethanol)	*730 million gallons* (73 - 110 million gals. of ethanol)

Conclusions

- **E diesel® faces important technical & regulatory challenges for the period 2004 – 2010.**
- **Tax equity (VEETC) needed for full market development.**
- **E diesel® needs consensus specification (e.g., ASTM).**
- **E diesel® will require QA/QC commercial guidelines.**
- **OEM acceptance remains a significant issue.**
- **E diesel® Consortium is now in place to address all issues.**